CLAIMS

What Is Claimed Is

1. A device comprising:

one or more acceleration measuring transducers to be positioned around a user's torso to detect the user's movement in one or more axes, at least one of the acceleration measuring transducers to provide an output signal corresponding to motion along one axis;

an altimeter to detect changes in altitude and provide a corresponding output signal; and

a processing unit communicatively coupled to the plurality of acceleration measuring transducers and the altimeter, the processing unit to receive one or more signals from the one or more acceleration measuring transducers and the altimeter and generate navigation information.

2. The device of claim 1 wherein the processing unit is configured to use the one or more acceleration signals and altimeter signal to

determine a nominal stride length,

deduce a type of step taken by a user,

determine a scaling multiplier for the deduced type of step, and

apply the scaling multiplier to the nominal stride length to estimate the correct distance traveled.

3. The device of claim 1 wherein the processing unit is configured to determine the slope of motion by

determining the number of steps taken by the user,

determining the horizontal distance traveled by multiplying the number of steps by a nominal stride length,

determining a change in elevation from the altimeter signal, and

dividing the change in elevation by the horizontal distance traveled.

4. The device of claim 3 wherein the processing unit is configured to use the slope information select a scaling multiplier to adjust the nominal stride length for purposes of accurately calculating distance traveled.

5. The device of claim 1 further comprising:

one or more magnetometers capable of sensing the earth's magnetic field, at least one magnetometer communicatively coupled to the processing unit to provide a signal corresponding to the direction of earth's magnetic field.

6. The device of claim 1 wherein the processing unit is configured to

determine acceleration changes over time from the one or more acceleration signals to determine an approximate direction of motion.

7. The device of claim 1 wherein the processing unit is configured to distinguish a either a forward or backward step movement from a sideways step movement.

8. The device of claim 7 wherein the one or more acceleration measuring transducers include

a forward/backward axis accelerometer providing a forward/backward acceleration signal,

a transverse axis accelerometer positioned approximately perpendicular to the forward/backward axis accelerometer and providing a transverse acceleration signal, and

wherein the processing unit is configured to distinguish between a forward or backward step movement from a sideways step movement by

calculating the square of the forward/backward acceleration signal to generate a variance,

calculating the square of the transverse acceleration signal to generate a variance,

calculating a covariance by multiplying the forward/backward acceleration signal by the vertical acceleration signal,

testing for correlation by multiplying the forward/backward-vertical covariance by the forward//backward variance.

determining a frequency of the walking steps for a user,

passing the variances and variance/covariance product through low-pass filter with a cut-off frequency approximately the frequency of walking steps for a user,

comparing the filtered forward/backward and transverse variances at a moment of step detection, and

if the transverse covariance exceeds the forward/backward variance by a pre-determined ratio, a sideways step is assumed,

otherwise, if the variance/covariance product exceeds a threshold, a forward step is assumed, otherwise a backward step is assumed.

9. The device of claim 1 wherein the one or more acceleration measuring transducers include

a transverse axis accelerometer positioned approximately perpendicular to the forward direction of motion and providing a transverse acceleration signal, and

wherein the processing unit is configured to distinguish the direction of a sideways step motion by monitoring characteristics of the transverse acceleration signal.

10. The device of claim 1 wherein the processing unit is configured to identify a running motion and adjust a nominal stride length to accurately account for distance traveled.

11. The device of claim 10 wherein the one or more acceleration measuring transducers include

a vertical axis accelerometer providing a vertical acceleration signal,

wherein the processing unit is configured to compensate for a running motion by

determining a difference between a maximum and minimum instantaneous vertical acceleration values within a most recent one step cycle,

dividing this difference by the time elapsed over the most recent one step cycle, and

if the quotient is greater than a threshold, a running motion is assumed and the nominal stride length is increased proportionally for purposes of dead reckoning calculations.

12. The device of claim 1 wherein the processing unit is configured to distinguish a forward step movement from a backward step movement based on the signals from the one or more acceleration measuring transducers.

13. The device of claim 12 wherein the one or more acceleration measuring transducers include

a forward/backward axis accelerometer providing an instantaneous forward/backward acceleration signal,

a vertical axis accelerometer providing an instantaneous vertical acceleration signal,

wherein the processing unit is configured to distinguish a forward step movement from a backward step movement by

calculating a variance by taking the square of the forward acceleration signal,

calculating a covariance by taking the product of the forward acceleration signal and the vertical acceleration signal,

calculating the instantaneous arithmetic difference between forward variance and forward-vertical covariance,

if, at the moment a step is detected, the difference is smaller than a threshold, the step is assumed to be a backward step,

otherwise, a forward step is assumed.

14. A method for navigating on foot comprising:

monitoring one or more acceleration sensors arranged mounted at a user's torso to measure acceleration along different axes; and

analyzing the acceleration changes over time to determine an approximate direction of movement with respect to a first direction.

15. The method of claim 14 further comprising:

measuring acceleration changes over time to determine the approximate change in distance between the user's steps due to a running step versus a walking step.

16. The method of claim 14 further comprising:

estimating the distance traveled between user steps based on the approximate direction of motion relative to a heading and slope.

17. A method comprising:

monitoring one or more accelerometers aligned along one or more axis;

generating a signal corresponding to the acceleration sensed along the corresponding axis;

monitoring an altimeter for an elevation signal;

deducing a type of step taken by a user, based on one or more of the acceleration signals;

determining a stride scaling multiplier for the deduced type of step; and

scaling the nominal stride length with the scaling multiplier to estimate the correct distance traveled.

18. The method of claim 17 further comprising:

determining the number of steps taken by the user;

determining the horizontal distance traveled by multiplying the number of steps by a nominal stride length;

determining a change in elevation from the altimeter signal; and

dividing the change in elevation by the horizontal distance traveled to obtain the slope of the terrain traveled.

19. A method to distinguish between a forward step and a sideways step comprising:

monitoring a forward acceleration signal;

monitoring a transverse acceleration signal, the transverse acceleration direction being perpendicular to the forward acceleration direction;

calculating the square of the forward/backward acceleration signal to generate a variance;

calculating the square of the transverse acceleration signal to generate a variance;

calculating the product of the forward/backward acceleration and the vertical acceleration to generate a covariance;

determining a frequency of the forward walking steps for a user;

passing the variances and covariance through low-pass filters with a cut-off frequency approximately the frequency of forward walking steps for a user;

comparing the filtered forward/backward variance and transverse variances at a moment of step detection; and

assuming a sideways step if the transverse variance exceeds the forward/backward variance by a ratio.

20. A method for distinguishing between right and left directions of travel, comprising:

monitoring a transverse acceleration signal, the transverse acceleration direction being perpendicular to the forward/backward acceleration direction; and

distinguish the direction of a sideways step motion by monitoring characteristics of the transverse acceleration signal.

21. A method for estimating distance traveled on foot, comprising:

identifying a running motion by

monitoring vertical acceleration,

determining a difference between a maximum and minimum instantaneous vertical acceleration values within a most recent one step cycle,

dividing this difference by the time elapsed over the most recent one step cycle; and

if the quotient is greater than a threshold, adjusting a nominal stride length to accurately account for distance traveled by multiplying the nominal stride length by a proportional scaling multiplier to accurately account for the distance traveled.

22. A method for distinguishing between forward steps and backward steps, comprising:

monitoring a forward/backward axis accelerometer;

monitoring a vertical axis accelerometer;

calculating a variance by taking the square of a forward/backward acceleration signal;

calculating a covariance by taking the product of the forward/backward acceleration signal and a vertical acceleration signal;

determining the product of the forward/backward variance and the forward/backward-vertical covariance;

assuming a backward step if, at the moment a step is detected, the product is smaller than a threshold; and

otherwise, assuming a forward step.